Organic Compounds:

↳ Compounds obtained from living sources i.e plants & animals.

Inorganic: non-living → minerals.

VFT: (Berzelius → 1815)

↳ We can't make organic compounds in lab. from inorganic compound or (non) living organism.

Rejection Of VFT:

→ 1828 → Wholer.

$NH_4CNO \longrightarrow H_2N-\underset{\underset{O}{\|}}{C}-NH_2$ → f.g: amide

Ammonium cyanate → Urea

Organic Compounds:

↳ Compounds of hydrocarbons and their derivative.

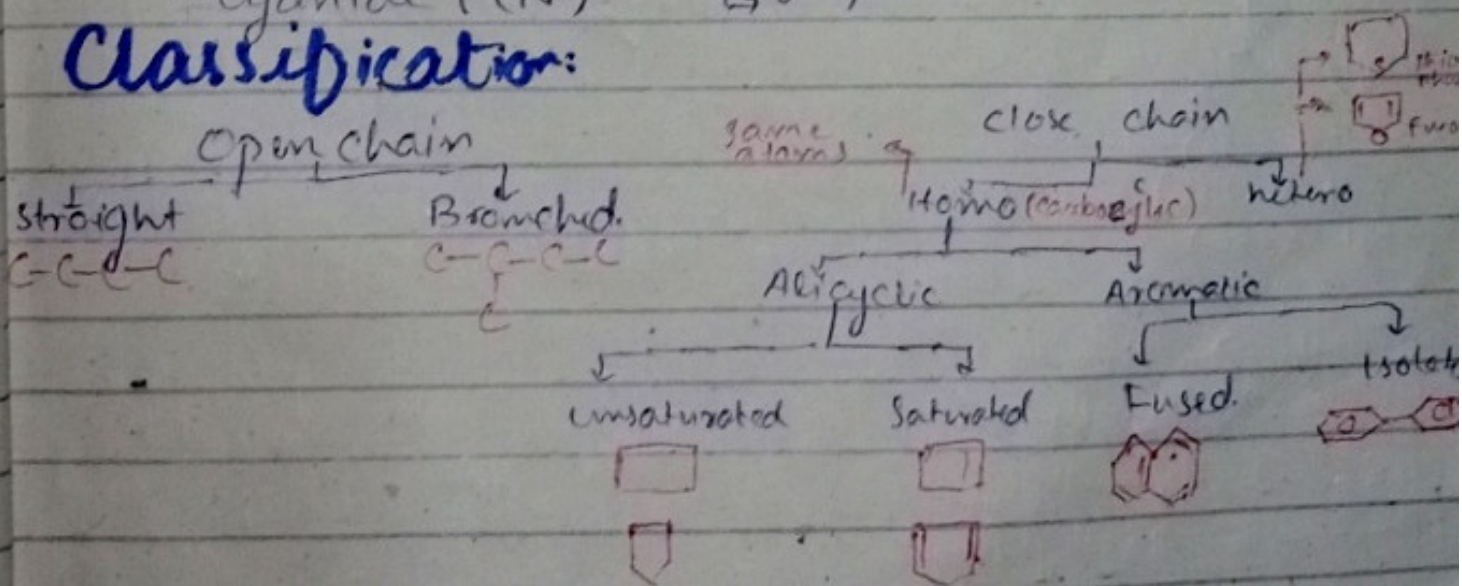
→ Essential → Carbon — hydrogen: no Carbon.

↳ Other → O, H, N, S

→ Inorganic compounds containing Carbon:

- → Oxide (CO, CO_2)
- → Sulphide (CS_2) → structure: match with inorganic; source: Inorganic; Properties: match with inorganic comp
- → Acid (HCN, H_2CO_3)
- → Carbonate (CO_3^{-2}) → Diamond, graphite
- → Cyanide (CN^-)

Classification:



a: n-butyl alcohol
b: O-xylene
c: Pyridene
d: Cyclo propane.

b → WOF is aromatic HC's
b & c → WOF is aromatic organic comp
b, c, d → WOF is closed chain O'c
c → Heterocyclic aromatic comp
a → acyclic organic compound.
b → homocyclic aromatic compound
b, d → homocyclic compound.
all → organic compound.

Isomerism

Isomer → Compound → same → molecular formula
different → structural formula

① Structural isomerism

② stereo isomerism.
→ same: structural & molecular formula but diff spatial arrangement of atoms.

Chain isom
Same → M.F
Diff → parent chain.

$CH_3-CH_2-CH_2-CH_3$

$CH_3-CH(CH_3)-CH_3$

shows
alkane (4C)
alkene (4C)
aldehyde 4C
ketone 5C
acids 4C
alkyne 5C

Position isomer.
same: M.F
same: functional gp
Diff: position of f.g.
Don't show:
alkane
aldehyde
carboxylic acid
Amide

$CH_3-CH_2-CH_2-OH$
n-propyl alcohol
1-propanol
$CH_3-CH(OH)-CH_3$
2-propanol
iso-propyl alcohol

F.g isomerism
same: M.F
Diff: F.g.
e.g.
→ alcohol & ether
alkanol alkoxy
→ aldehyde & ketone
alkanal alkanone
→ Acid & Ester.
alkanoic

Metamerism:
same: M.F
same: F.g
Diff: Distribution of C. around F.g
→ Ether (4C)
→ Ketones (5C)
→ Esters (3C)
→ Sec. amine (4C)

$CH_3-CH_2-O-CH_2-CH_3$
$CH_3-O-CH_2-CH_2-CH_3$

$CH_3-C(=O)-O-CH_3$ methyl acetate
$CH_3-CH_2-C(=O)-O-CH_3$ ethyl formate

Tautomerism
same: M.F
different: position of H
position of π bond.
→ Equilibrium established.

$CH_3-C(=O)-CH_3 \rightleftharpoons CH_3-C(OH)=CH_2$
keto enol

Stereoisomerism.

Optical isomer
- isomer that show diff interaction PPL
- +/D-isomer → right
- -/L-isomer → left

Geometrical
→ Cis-trans isomer
condition:
↳ no free rotation
↳ alkene
↳ cycloalkene

alkene:
cis:
a → less stable → more reactive
b → ≠ to a

trans:
a → more stable → less reactive
b → ≠ to a

W.O.F shows cis-trans?
✗ a: 1 butene
✓ b: 2 butene
✗ c: 2,3 dimethyl 2 butene
✓ d: 1,2 dichloro propane

cycloalkane:
↳ No free rotation
↳ diff gp at adjacent carbon

e.g.

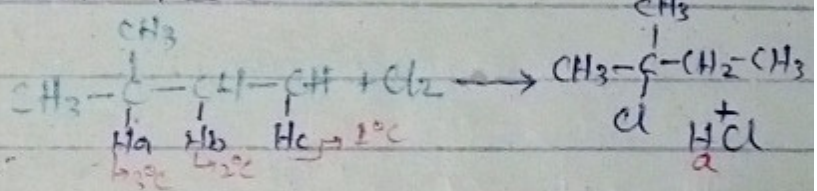
Hydrocarbon:

Chemistry Of Alkane:

→ Free radical substitution reaction.

→ $F_2 > Cl_2 > Br_2 > I_2$

→ $3H^\circ > 2H^\circ > 1H^\circ$

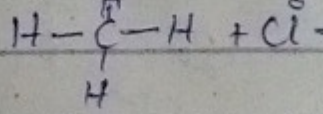


Mechanism:

Initiation: Formation of Free radical

$$Cl-Cl \xrightarrow{h\nu} Cl^\circ + Cl^\circ$$

Propagation:
(Formation as well as consumption of free radical)



$$CH_3^\circ + Cl-Cl \longrightarrow CH_3Cl + Cl^\circ$$

$$\longrightarrow CH_2Cl_2$$

$$\longrightarrow CHCl_3$$

$$\longrightarrow CCl_4 \text{ - only nonpolar}$$

1: Propagation bond form?
↳ Polar (C-Cl)

2: Propagation bond break?
↳ Non-polar (C-H)

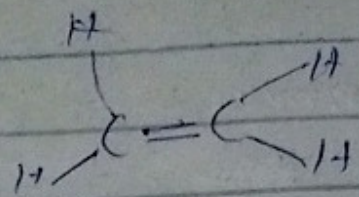
3: Propagation product?
↳ polar
+
Nonpolar (CCl_4)

Termination

$$Cl^\circ + Cl^\circ \longrightarrow Cl_2$$

$$CH_3^\circ + Cl^\circ \longrightarrow CH_3Cl$$

Chemistry Of Alkenes:



→ Ethene

→ Unsaturated (double bond)
→ Olefins (oil forming)
→ Each → sp^2
→ Geometry → planar

Preparation:

1: Dehydration of alcohol.
→ Removal of H_2O

Dehydrating agents: P_2O_5 / Conc. H_2SO_4 / Al_2O_3

$3^\circ > 2^\circ > 1^\circ$

$$H_2C(\beta)-CH_2(\alpha)-OH \xrightarrow[140-170^\circ C]{\text{conc. } H_2SO_4} H_2C=CH_2 + H_2O$$

2: Dehydrohalogenation of R-X:

$$CH_3-CH_2-Cl \xrightarrow{KOH} CH_2=CH_2 + KCl + H_2O$$

- WOF will produce isobutylene? (c)
- WOF will produce 2-butene? a will produce 2 butene; more
- WOF will produce propylene? a & b

a: Isopropyl alcohol
b: Isopropyl chloride
c: Ter-butyl alcohol
d: n-butyl chloride.

Reactions:

- $CH_2=CH_2$

Hydrogenation: $\xrightarrow[200-300^\circ]{H_2/Ni/Pt/Pd} CH_3-CH_3$

Halogenation: $\xrightarrow[\text{To check unsaturation}]{Br_2/CCl_4 \text{ (reddish)}}$ $CH_2(Br)-CH_2(Br)$ vicinal dihalide.

Epoxidation: $\xrightarrow{Ag_2O/300^\circ}$ H_2C-CH_2 (cyclic ether, Oxirane, Ethylene oxide)

$CH_3-\overset{O}{\overset{\|}{C}}-OOH$

Polymerization: $\left(CH_2-CH_2-CH_2-CH_2\right)_n$ polythene.

Ozonolysis: $CH_2=CH_2 \xrightarrow{Zn/H_2O} H-\overset{O}{\overset{\|}{C}}-H + H-\overset{O}{\overset{\|}{C}}-H$

carbonyl compounds: $CH_3-CH=CH_2 \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-H + H-\overset{O}{\overset{\|}{C}}-H$

$CH_3-\underset{CH_3}{C}=\underset{CH_3}{C}-CH_3 \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + CH_3-\overset{O}{\overset{\|}{C}}-H \longrightarrow CH_3-\underset{CH_3}{\underset{|}{C}}(OH)-\underset{H}{\underset{|}{C}}(OH)-CH_3$

2 methyl 2-butene. $CH_3-\overset{2}{\underset{CH_3}{\underset{|}{C}}}=\overset{3}{C}H-\overset{4}{C}H_3$

Hydroxylation: $CH_2-CH_2 + MnO_2 + H_2O$.
$KMnO_4$ / Bayers reagent. $\quad OH \quad OH$

Reactions that follow markonikovs Rule:

Unsymmetrical alkene: unequal no. of H. atoms around double bond. $CH_3-CH=CH_2$

Unsymmetrical reagent: unequal charge distribution. $\overset{+}{H}-\overset{-}{X}$

Hydrohalogenation: $\xrightarrow[HI>HBr>HCl>HF]{H-X} CH_3-\underset{X}{\underset{|}{C}}H-\underset{H}{\underset{|}{C}}H_2$ alkyl halide.

$CH_3-CH=CH_2 \xrightarrow[H_2SO_4]{H-OH} CH_3-\underset{OH}{\underset{|}{C}}H-\underset{H}{\underset{|}{C}}H_2$ alcohol.

$\xrightarrow{X-OH} CH_3-\underset{OH}{\underset{|}{C}}H-\underset{X}{\underset{|}{C}}H_2$ Halohydrin.

→ only ethene will form primary alcohol and primary alkyl halide.

Chemistry of Alkynes

→ Unsaturated HC's
→ H–C≡C–H
→ Linear
→ sp → hybridization.
→ Bond angle → 180°.

Preparation:

1: From Vicinal dihalide:

$$H_2C(Cl)-CH_2(Cl) + KOH \xrightarrow{\text{alcohol}} HC(Cl)=CH_2 + KCl + H_2O$$

vinyl chloride
1-chloroethene

$$HC(Cl)=CH(H) + NaNH_2 \longrightarrow HC\equiv CH + NaCl + NH_3$$

2: From tetrahalides:

$$H-C(X)(X)-C(X)(X)-H + 2Zn \longrightarrow HC\equiv CH + 2ZnX_2$$

Reactions: (Electrophillic addition + Substitution)

1: Hydrogenation:

$$\underset{sp}{CH}\equiv\underset{sp}{CH} \xrightarrow[+H_2]{Ni/Pt/Pd} \underset{sp^2}{H_2C}=\underset{sp^2}{CH_2} \xrightarrow{+H_2} \underset{sp^3}{CH_3}-\underset{sp^3}{CH_3}$$

2: Hydrohalogenation:

$$HC\equiv CH + H-X \longrightarrow \underset{\text{vinyl halide}}{H_2C=CH(X)} \longrightarrow \underset{\text{geminal dihalide}}{CH_3-CH(X)_2}$$

3: Hydration:

$$HC\equiv CH \xrightarrow[H_2SO_4/HgSO_4]{H-OH} \underset{\text{vicinyl alcohol}}{H_2C=CH-OH} \rightleftharpoons \underset{\text{acetaldehyde}}{CH_3-C(=O)-H}$$

tautomerization

$$H_2C=C(-H)-O-H$$

Chemistry of Alkynes

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2: Hydrohalogenation:

$$HC\equiv CH + H-X \longrightarrow \underset{\text{vinyl halide}}{H_2C=CH(X)} \longrightarrow \underset{\text{geminal dihalide}}{CH_3-CH(X)_2}$$

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$$HC\equiv CH \xrightarrow[H_2SO_4/HgSO_4]{H-OH} \underset{\text{vicinyl alcohol}}{H_2C=CH-OH} \rightleftharpoons \underset{\text{acetaldehyde}}{CH_3-C(=O)-H}$$

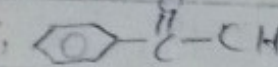
tautomerization

$$H_2C=C(-H)-O-H$$

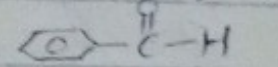
Ethyne → Acetaldehyde
Other alkyne → Ketone → Aromatic
aliphatic

WOF is produced by hydration of ethyne?

a: $H-C\equiv C-H$

b:  acetophenone.

c: $CH_3-CH_2-C\equiv C-H$

d: 

Acidity Of Terminal Alkyne.

- $CH_3-C\equiv C-CH_3$ (non terminal) → Non acidic
- $CH_3-CH_2-C\equiv CH$ (Terminal → acidic).

sp hybridized
Max electronegativity → 50% s character.
Min of C at 0% s character.

$CH_3-CH_2-C\equiv C^{-\delta}-H^{+\delta}$
↳ polar bond. → Now base can remove H of ter alkyne.

Reactions:

$H-C\equiv C-H + 2Na \longrightarrow NaC\equiv CNa + H_2\uparrow$
Sodium acetaldehyde.
Ionic compound.

$CH_3-C\equiv CH + NaNH_2 \longrightarrow CH_3-C\equiv CNa + NH_3$

→ Used to differentiate b/w ter and non ter alkyne.
→ " " " Ethene and ethyne.

Reaction: Tollens reagent

$H-C\equiv C-H + AgNO_3 + NH_4OH \longrightarrow AgC\equiv CAg + NH_4NO_3 + H_2O$
white ppt

$H_2C=CH_2 + AgNO_3 + NH_4OH \longrightarrow No$

$HC\equiv CH + Cu_2Cl_2 + NH_4OH \longrightarrow CuC\equiv CCu + NH_4Cl + H_2O$
Red ppt

Acidic Order:

$HC\equiv CH > CH_3-C\equiv CH$

Acidity ↓ No. of C atom ↑

Ethyne > Ethene > Ethane

$HC \equiv CH > H_2C = CH_2 > CH_3 - CH_3$

$R-\overset{O}{\overset{\|}{C}}-OH > \text{C}_6\text{H}_5\text{OH} > H_2O > C_2H_5-OH > HC \equiv CH$

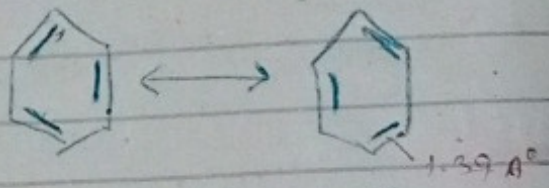
Aromatic Hydrocarbons:

Benzene:

→ Empirical formula: CH
→ Molecular formula: C_6H_6
→ Aromatic Hydrocarbon.
→ Follows huckle rule: $4n+2$ πe^- n = rings
benzene has 1 ring
$4(1)+2 = \boxed{6\ \pi e^-}$

Structure of benzene:

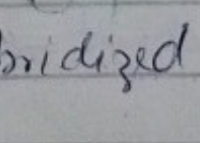
Kekules: (Theoretical)
- Cyclic / Hexagonal / planer
- 3 - double bonds.
- 3 - single bonds.



X-ray study of benzene: (Experimental)
→ Cyclic structure / Hexagonal / planer
→ C—C (1.39 A°)
→ C—H (1.09 A°)
→ 120°

MOT Aspect of Benzene:
→ There are 6 carbons and each carbon is sp^2 hybridized.

$sp^2 \rightarrow 1s + 2p \rightarrow 3$



Each carbon → one unhybridized p orbital.

Bonds

σ (sigma)
Linear
↳ $sp^2 - sp^2$ (C–C) [six]
↳ $sp^2 - s$ (C–H) [six]

π (sidewise)
→ p–p
{ + }
→ 3π bond

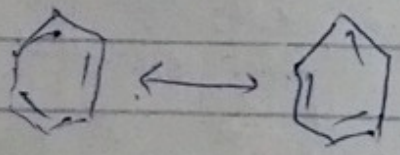
Total : 15 bonds

Bond pair of benzene = 15 B. pair
total ē of benzene = 30ē
total π ē = 6
total π ē pair = 3
total sigma ē = 24
total sigma ē pair = 12

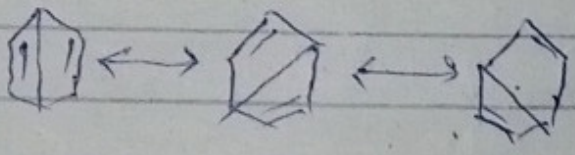
Stability Of Benzene:

Stability ∝ Resonating structure. → Delocalization of π ēs

Kekule's



Dewar's



Resonance energy = 150 kJ/mol

Heat of hydrogenation ∝ 1/stability

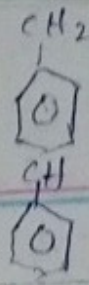
Benzene = 208 kJ/mol (less)

Reaction Of Benzene & Toluene:

Addition (Reluctant)
→ It loose its identity
behaves → Unsaturated comp

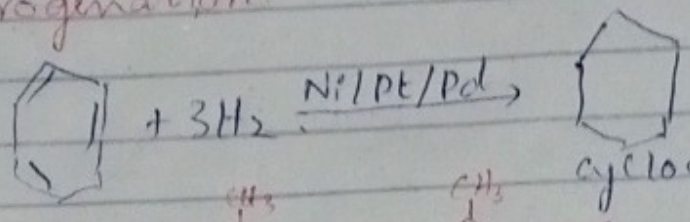
Electrophilic substitution
(Characteristic)
→ Identity retained no bond breaking
→ behaves as saturated comp.

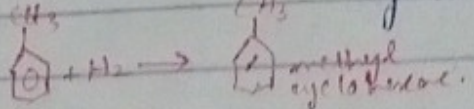
→ Benzene doesn't form polymer.



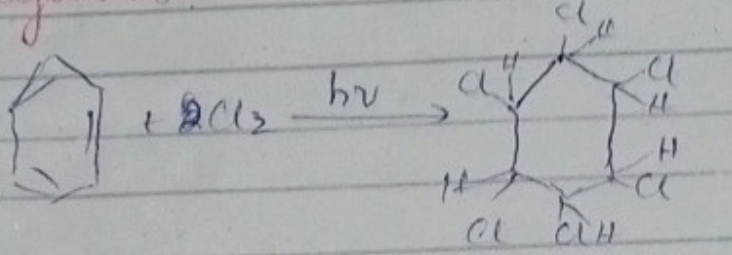
Addition:

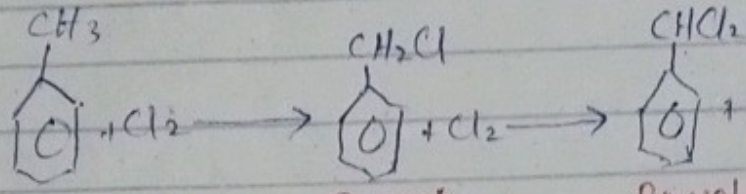
1: Hydrogenation:



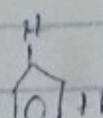
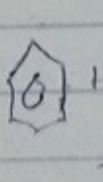
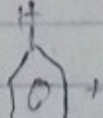
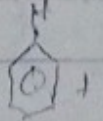
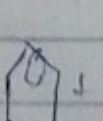


2: Halogenation:





Electrophilic Substitution:

	E+	Catalyst	Reaction.
1: Nitration: (NO_2)	NO_2^+ Nitronium	H_2SO_4	
2 Sulphonation (SO_3H)	SO_3	H_2SO_4	
3: Halogenation X_2 (Br_2, Cl_2)	Cl^+ Chloronium	$AlCl_3$ $FeCl_3$ BF_3	
4: Friedal Crafts alkylation	CH_3^+	$AlCl_3$ $FeCl_3$ BF_3	
5: Friedal Crafts Acylation	$CH_3-C^+=O$	$AlCl_3$ $FeCl_3$ BF_3	

W.O.F will be the product of Benzene & n-propyl chloride?

a: Ethyl benzene

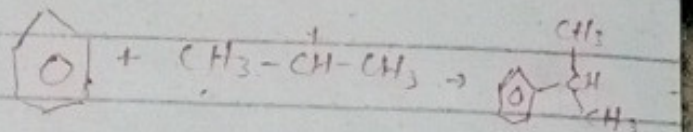
b: n-propyl benzene → it will not be made.

✓c: Cumene.

✓d: iso propyl benzene.

$CH_3-CH_2-CH_2-Cl + FeCl_3 \rightarrow CH_3-CH_2-CH_2^+$ primary unstable

$CH_3-\overset{+}{C}H-CH_3$



Choose the product of rx b/w benzene & propenyl chloride.

a: methyl phenyl ~~chloride~~ ketone

(b) Ethyl phenyl ketone

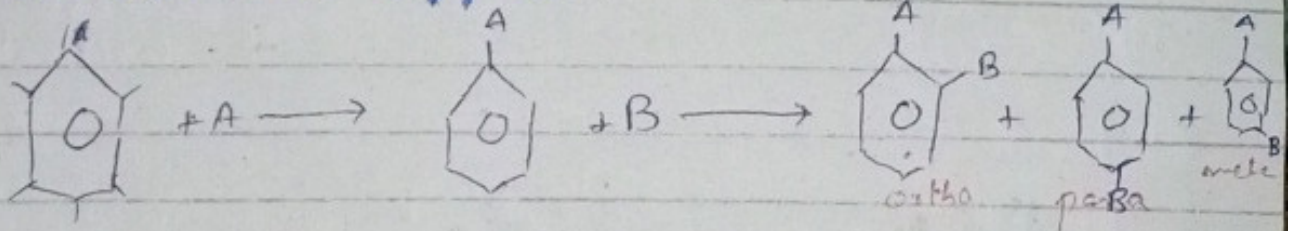
c: Diphenyl ketone

d: none.

$CH_3-\overset{O}{\overset{\|}{C}}-Cl$ } Ethyl chloride

$CH_3-CH_2-\overset{O}{\overset{\|}{C}}-Cl$] propanoyl chloride

Substituent Effect:



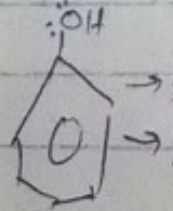
Ortho-para director

→ Activator

→ Reactivity of benzene ↑

→ $\bar{e}$ density ↑ at ortho para

R, OR, OH, NH_2, -NHR, $-NR_2$



→ lone pairs

→ except 'R'

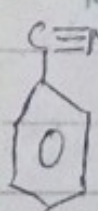
Meta director

→ Deactivator.

→ Reactivity of Benzene ↓

→ $\bar{e}$ density decreases.

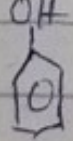
→ CN, COR, SO_3H, $COOH$, -CHO, $-NO_2$, $-\overset{+}{N}(R)_3$

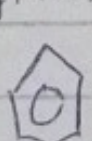


↳ multiple bond

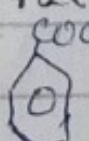
↳ Central metal atom

W.O.F gives slowest rxn on nitration?

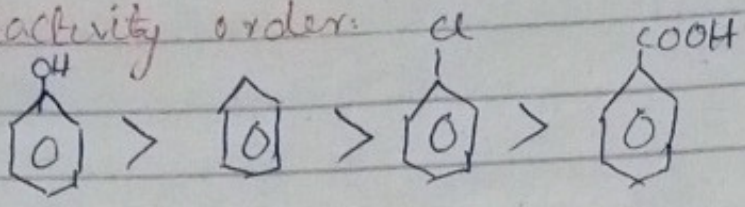
a: 

b: 

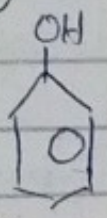
c: 

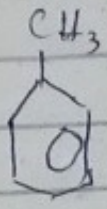
d: 

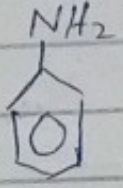
Reactivity order:

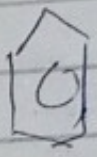


mcq:

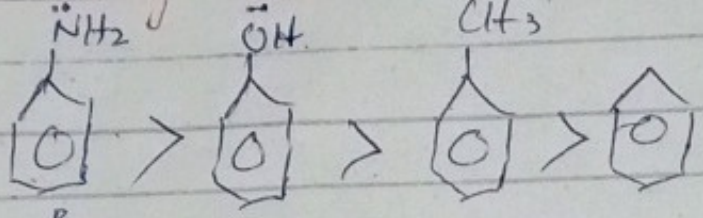
a 

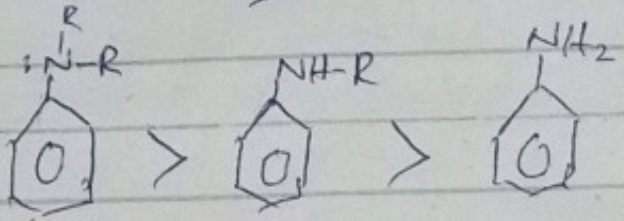
b: 

c: 

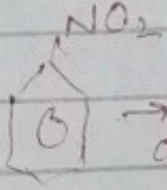
d: 

Reactivity order:





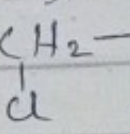
most activator



→ most deactivator

Alky Halide:

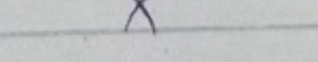
Wof is alkyl halide?

a: CH_3Cl b: CH_2Cl_2 c:  d: All of the

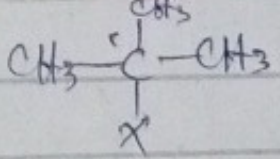
halo alkenes but not alkyl halide

Haloalkane (halogen derivative of alkane)

mono (Alky R–X halide) → CH_3Cl → $1^\circ RX$ → CH_3-CH_2-X

dihalo → CH_2Cl_2 → $2^\circ RX$ → 

trihalo → $CHCl_3$

Tetrahalo. → CCl_4 → $3^\circ RX$ → 

a: n-pentyl chloride ✓ primary
b: iso pentyl chloride ~~ster~~ primary.
c: neo pentyl chloride primary
d: All of these

→ All 'n', all 'iso', all 'neo' are primary alkyl halide or alcohol except iso propyl alcohol and iso propyl halide.

Q: iso propyl chloride (2° RX) — except
b: (n)-butyl bromide (1° RX)
c: ter-butyl chloride. (3° RX)
d: (iso) butyl chloride (1° RX)

a: n-butyl chloride (1° RX)
b: Iso-pentyl chloride (1° RX)
c: Sec butyl chloride (2° RX)
d: tert butyl chloride (3° RX).

Reactivity Order:

Reactivity ∝ Bond Length

Reactivity ∝ $\frac{1}{\text{Bond energy}}$

∴ Bond energy is the reactivity factor.

Reactivity ∝ size of halogen.

Toward Nucleophile:

R-I > R-Br > R-Cl > R-F

$CH_3-I > C_2H_5-I > C_3H_7I$

3° RX > 2° RX > 1° RX

Nucleophile:
↳ Nucleus lover
↳ Electron rich
$OH^-, Cl^-, Br^-/H_2O/NH_3$

Electrophile
↳ Electron lover
↳ Electron deficient
$BF_3/BH_3/AlCl_3/SO_3H/NO_2^+$

mcq: Electrophile except
a: H^+ (b) NH_3
c: CH_3^+ (d) H_3O^+
↳ b/c octet is complete.

Carbocation:
↳ Form when: bond is broken heterolytically
↳ Form when: electrophilic addition.
↳ $3^\circ > 2^\circ > 1^\circ$
↳ reactivity order + stability order.

Reactions:

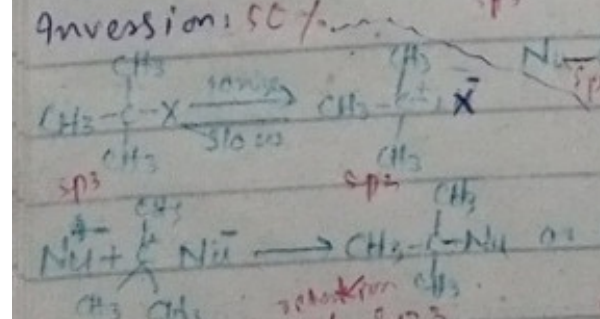
Attack → Nu
Attack at α-C
End → substituted product

Beta 'H' must be present
↳ Attack → base
↳ End p → unsaturated

Nucleophilic (SN)

Elimination

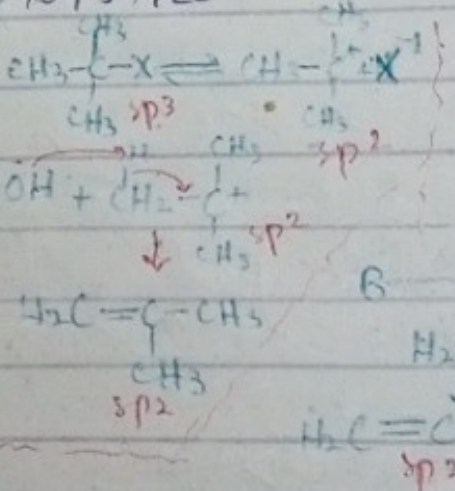
SN1:
→ two step rxn:
↳ 1st step slow RDS
↳ 2nd step fast
→ Unimolecular
→ 1st order
↳ Rate = [RX]
→ Polar Solvent
→ Substrate: Ter RX
→ sp^3 sp^2 sp^3
tetra planar tetra
109.5 - 120 - 109.5
Retention: 50%
Inversion: 50%



SN2:
→ One step
↳ 2nd slow (RDS)
→ Biomolecular
→ 2nd Order
→ Rate = [RX][Nu]
→ Non polar
→ Sub: CH_3X
//
//
//
↳ Inversion 100%

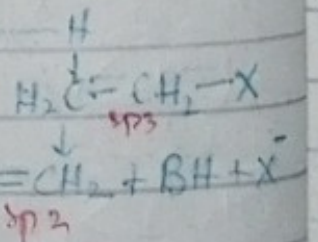
E1:
// S_N1

$sp^3 \rightarrow sp^2$
Tetra → planar
109.5 → 120°



E2:
// S_N2

$sp^3 \rightarrow sp^2$
tetra → planar
109.5 → 120°



∴ Iodine is a very good nucleophile and leaving grp.

General Reactivity Order (S_N)'s

$1^\circ RX > 2^\circ RX > 3^\circ RX$

General Reactivity Order (Elim)

$3^\circ RX > 2^\circ RX > 1^\circ RX$

Factors:	Substitution	Elemination.
→ Substrate:	Less Crowded.	Crowded substrate
→ Base	Weak.	Strong
→ Nucleophile	Good	Poor.
→ Leaving gp	S_N1 → no role S_N2 → good	E_1 → no role. E_2 → poor
→ Temperature	Low	High.

F^- Strong base
Weak nucleophile

Cl^-

Br^-

I^- Weak base
Good nucleophile

$CH_3-O^- + CH_3-CH_2-Cl \longrightarrow$ $CH_2=CH_2 + H^+ + Cl^-$

CH_3-S^- $CH_3-CH_2-\overset{+}{S}(CH_3)_2\,Cl^-$

$CH_3-CH_2-S-CH_3$

CH_3-CH_2-OH $\xrightarrow{200^\circ C}$ elimination

$\xrightarrow{100^\circ C}$ substitution

Electrophilic substitution: C-/H

1: With metal:

$$\xrightarrow{Na} CH_3-CH_2-\ddot{O}Na^+ + \tfrac{1}{2} H_2\uparrow$$

2: Carboxylic acid:

$$CH_3-CH_2-OH + CH_3-\overset{O}{\overset{\|}{C}}-OH \underset{}{\overset{H^+}{\rightleftharpoons}} CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5 + H_2O$$

ester

3: Grignard reagent

$$CH_3-CH_2-OH + CH_3-Mg-Br \longrightarrow CH_4 + Mg\begin{matrix} Br \\ OC_2H_5 \end{matrix}$$

Nucleophilic substitution: C-/O

1: With alkyl halide (Lucas test)

→ alcohol can't react with NaOH b/c it is weak acid.

$$CH_3-CH_2-OH \xrightarrow{HCl/ZnCl_2} CH_3-CH_2-Cl + H_2O$$

↳ 3° alcohol will form oily layer faster
↳ after 5 to 10 minutes 2° OH
↳ after strong heating 1° OH

↳ Alkyl halide forms oily layer.

2: With $SOCl_2$:

$$\xrightarrow{\text{pyridine}} CH_3-CH_2-Cl + HCl + SO_2$$

3: With PCl_3:

$$\longrightarrow 3\,CH_3-CH_2-Cl + H_3PO_3$$

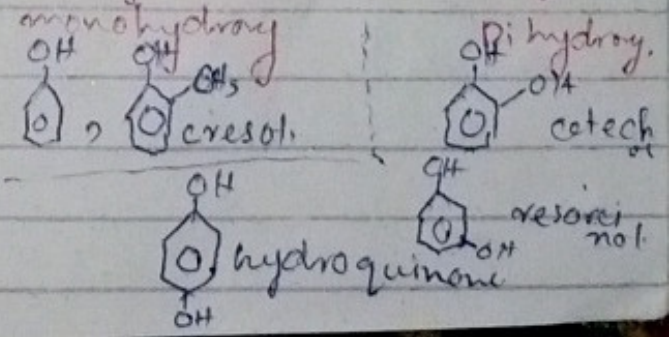
4: With PCl_5:

$$\longrightarrow CH_3-CH_2-Cl + HCl + POCl_3.$$

Phenol:

↳ hydroxy derivative of benzene.
↳ 5% aqueous solution of phenol is known as carbolic acid.
↳ phene → name derived.
↳ C_6H_5-OH ; $Ph-OH$

classification



→ Alcohl	Phenol	Carboxylic acid.
Na	Na	Na ✓
~~NaOH~~ ✗	NaOH	NaOH ✓
~~CH_3~~ ✗	~~CH_3~~ ✗	CO_3^{2-} ✓

Physical Properties:

→ Colorless liquids or deliquesent solid crystalline
→ M.pt → 41°C
→ B.pt → 182°C
→ RTP → partial misable → pink solution
→ 68.5°C → complete soluble
↳ upper consulate temperature

Acidity Of Phenol:

→ React with Na & NaOH
→ No effect on litmus paper
→ No reaction with carbonates & bicarbonates.
⇝ Acidic order:

$$R-\overset{O}{\overset{\|}{C}}-OH > \text{C}_6\text{H}_5\text{OH} > H_2O > C_2H_5-OH$$

$$K_a > K_a > K_a > K_a$$

$$pK_a < pK_a < pK_a < pK_a$$

Lowest pH
max H^+

Highest pH
min H^+

mcq: WOF will have highest pKb & Kb?
a: CH_3COO^- (max pKb) b: $C_6H_5O^-$ c: OH^- d: $CH_3CH_2O^-$ (max Kb)

⇝ Basicity Order:

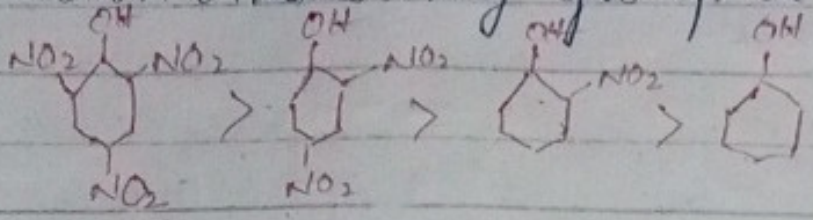
$$CH_3CH_2O^- > OH^- > C_6H_5O^- > CH_3COO^-$$

$$K_b > K_b > K_b > K_b$$

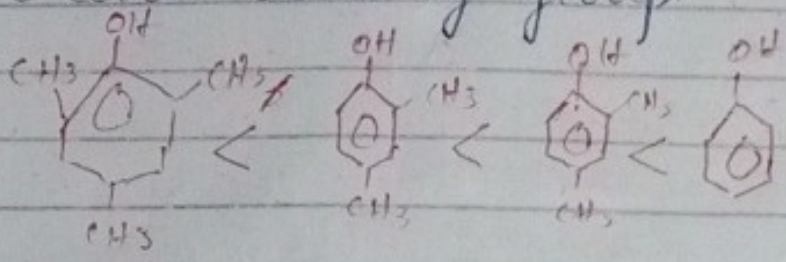
$$pK_b < pK_b < pK_b < pK_b.$$

↳ Strong acid will have weak base
↳ Weak acid will have strong base.

→ Acidity of phenol increases in presence of electron withdrawing group at ring.

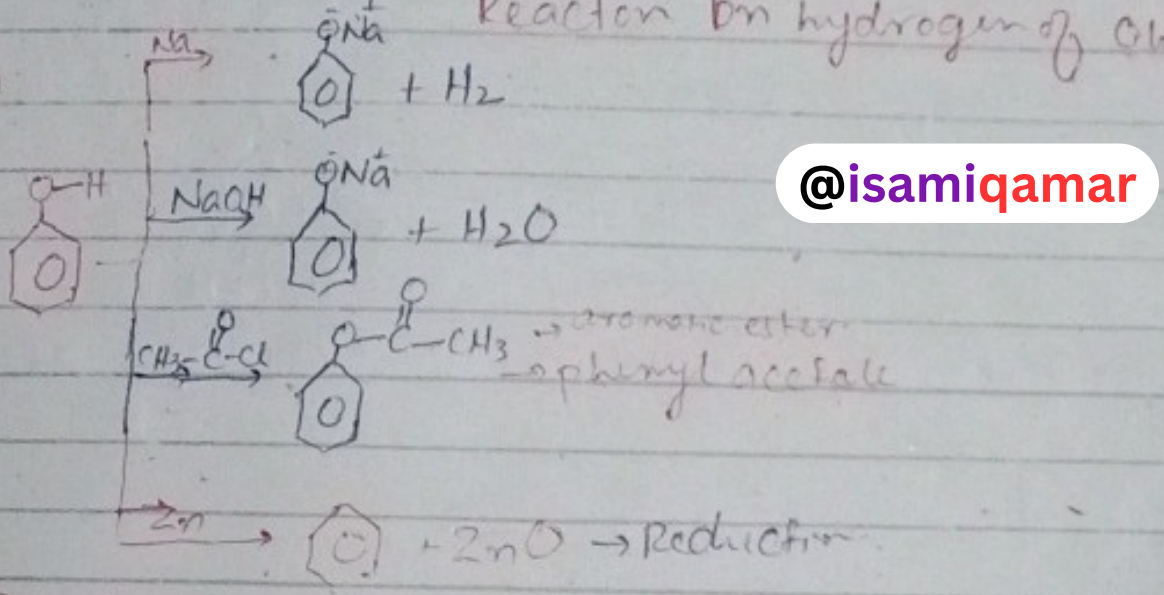


→ Acidity of phenol decreases in presence of electron donating group.

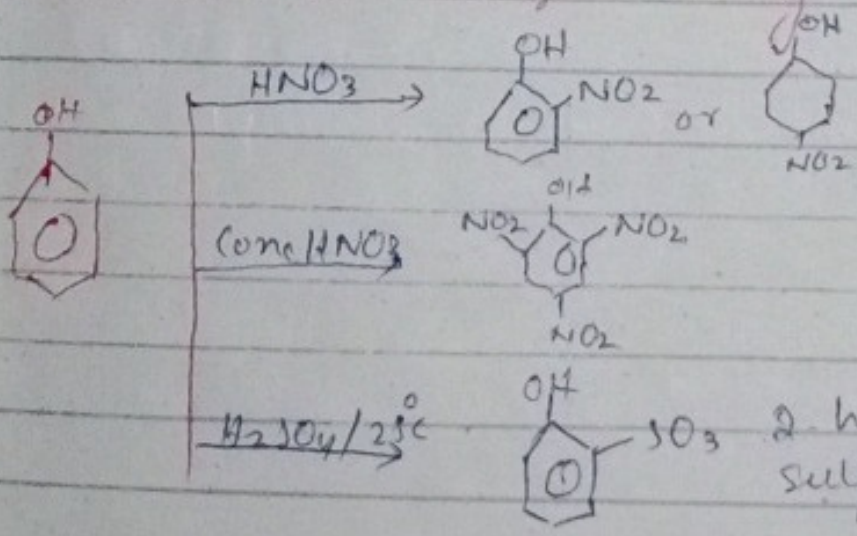


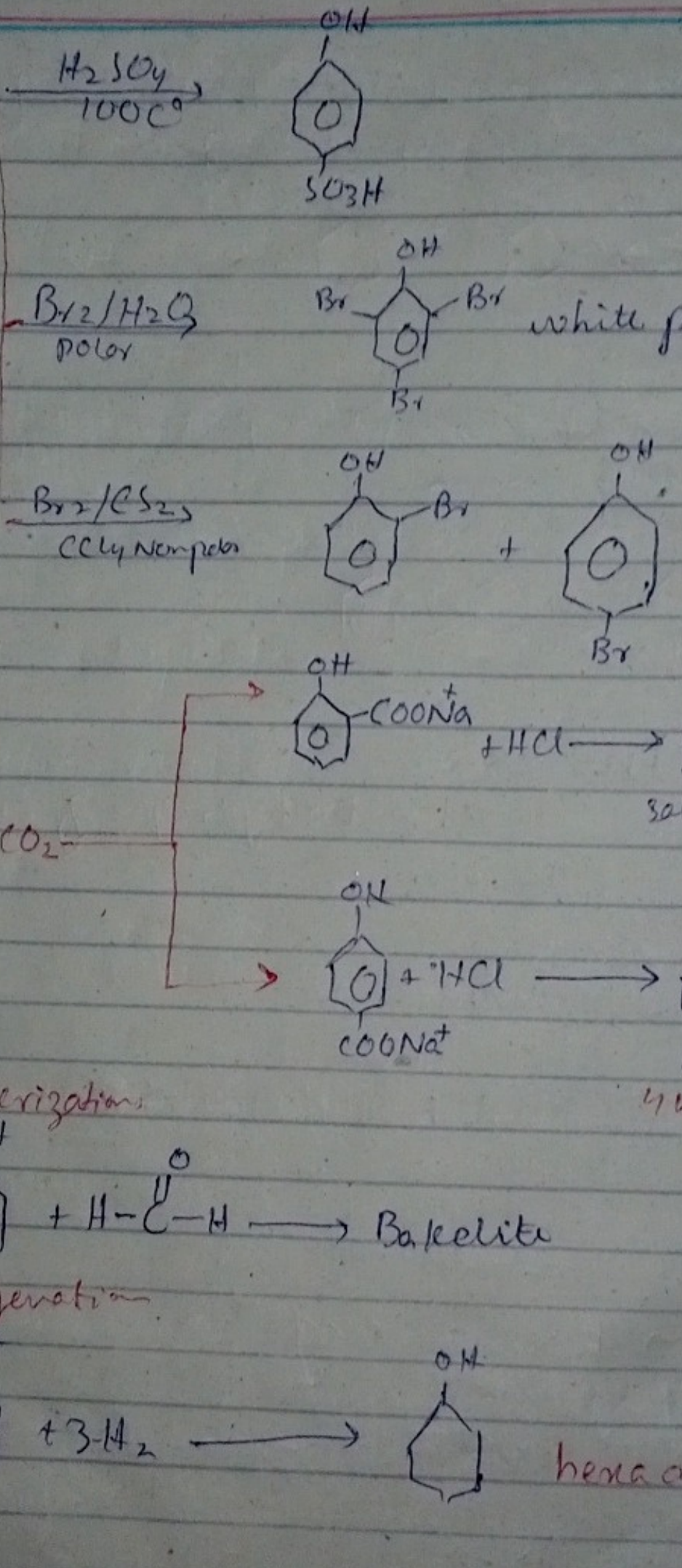
Reactions of Phenol:

Reaction on hydrogen of OH:



Reaction on benzene ring:




H2SO4
100C°
SO3H
Br2/H2O
polar
white ppt.
Br2/CS2
CCl4 Non polar
+
+HCl
+NaCl
salicylic acid.
2 hydroxy benzoic acid
+CO2
+HCl
+NaCl
4 hydroxy benzoic acid
Polymerization:
+ H-C-H
Bakelite
Hydrogenation:
+3H2
hexa alcohol

Aldehyde & Ketone.

(formyl) $-\overset{O}{\overset{\|}{C}}-H$

→ $R-\overset{O}{\overset{\|}{C}}-H$

$C_nH_{2n}O$

→ glucose

→ reducing agent

→ more reactive

e.g: $H-\overset{O}{\overset{\|}{C}}-H$

$CH_3-\overset{O}{\overset{\|}{C}}-H$

$-\overset{O}{\overset{\|}{C}}-$ (Keto) (oxo)

→ $R-\overset{O}{\overset{\|}{C}}-R$

$C_nH_{2n}O$

→ fructose

→ Weak reducing agent.

→ less reactive.

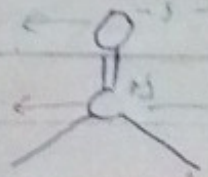
e.g $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$.

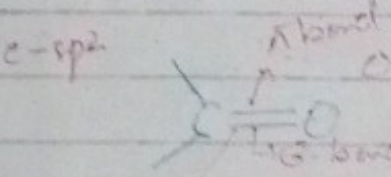
→ minimum 3-C are required.

Structure of Carbonyl.

Attack by E^+

Attack by Nu^-





* polar bond.
* Nu addition reaction.

Preparation methods:

→ ozonolysis of alkene

→ Hydration of alkyne (only ethyne forms aldehyde)

→ Oxidation of alcohol

→ Fridal craft acylation.

Reactivity of carbonyl:

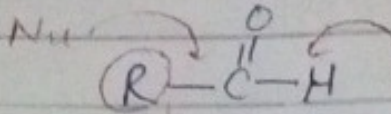
Aldehyde > Ketone.

∴ All aldehydes are more reactive than all ketones

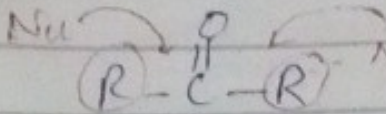
$H-\overset{O}{\overset{\|}{C}}-H > CH_3-\overset{O}{\overset{\|}{C}}-H > CH_3-CH_2-\overset{O}{\overset{\|}{C}}-H > CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

Reasons

Steric Hindrance



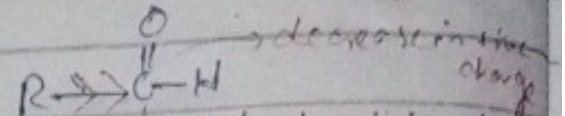
more R, less S.H



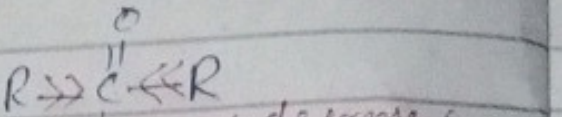
less R, more S.H

→ increases the nucleophilic character

Electron donating effect



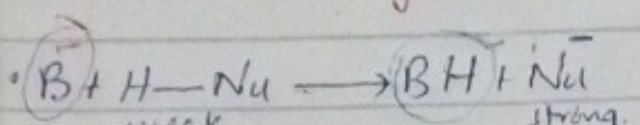
→ decrease in the charge
electrophilic character decrease ↓

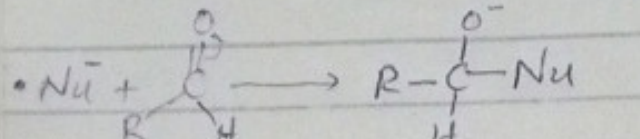


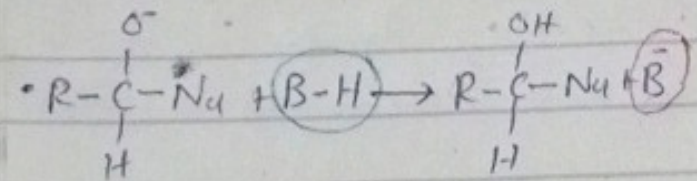
more decrease in electrophilic character

Reaction of aldehyde & ketone:

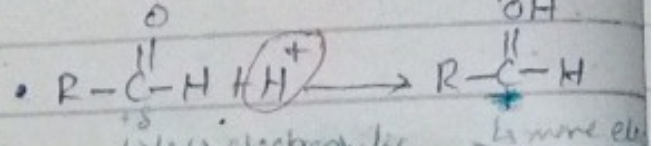
→ Base Catalyzed Rx





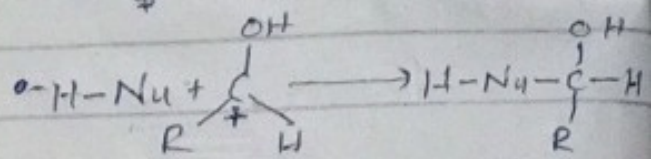


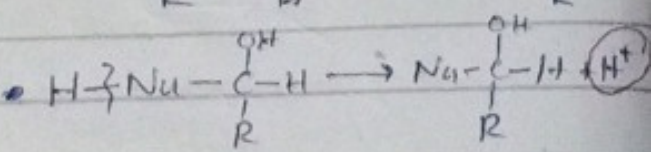
→ Acid Catalyzed reaction



less electrophilic

more electrophilic

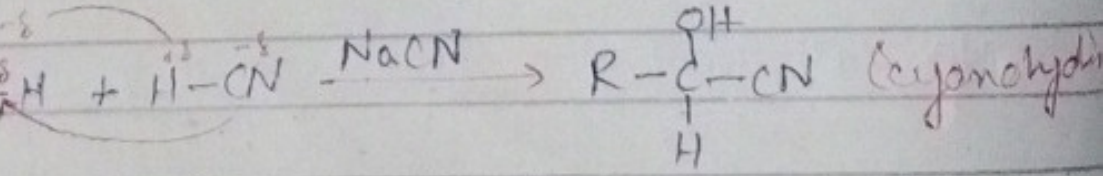




Base Catalyzed Reaction:

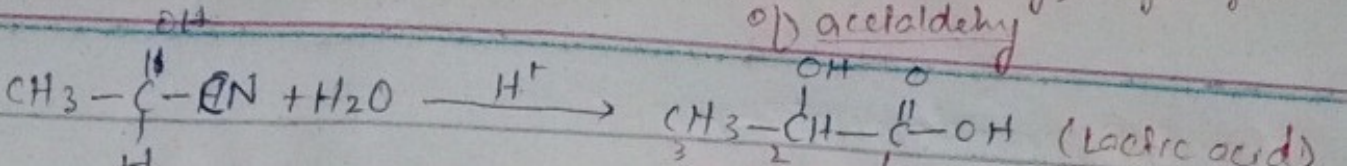
1: Rxn with HCN
2: Rxn with sodium hydrogen sulphide ($NaSO_3H$)
3: Aldole condensation reaction
4: Kanizaros reaction
5: Haloform reaction

1:

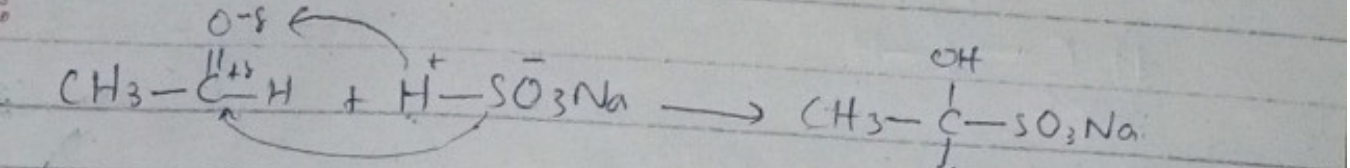


Cyanohydrin

→ lactic acid can only form from acid catalyzed hydrolysis of acetaldehyde



2:



↳ all aldehyde
↳ only methyl ketones.

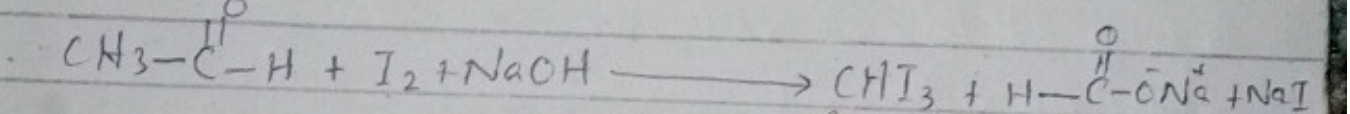
label aldehyde and ketone

→ Separate carbonyl compounds from non carbonyl compound

mixture of ketone & alcohol separated by?
a: HCN b: RMgX (c) $NaHSO_3$ d: All

UNOF cant react with $NaHSO_3$? which can't give white ppt?
a: ethanal (b) diethyl ketone c: propanal.

⑤: Haloform



→ aldehyde → only acetaldehyde
→ Ketone → only methyl ketone
→ 1° ROH → only CH_3-CH_2-OH (ethanol)
→ 2° ROH → 2-alkanol
→ 3° ROH → no reaction

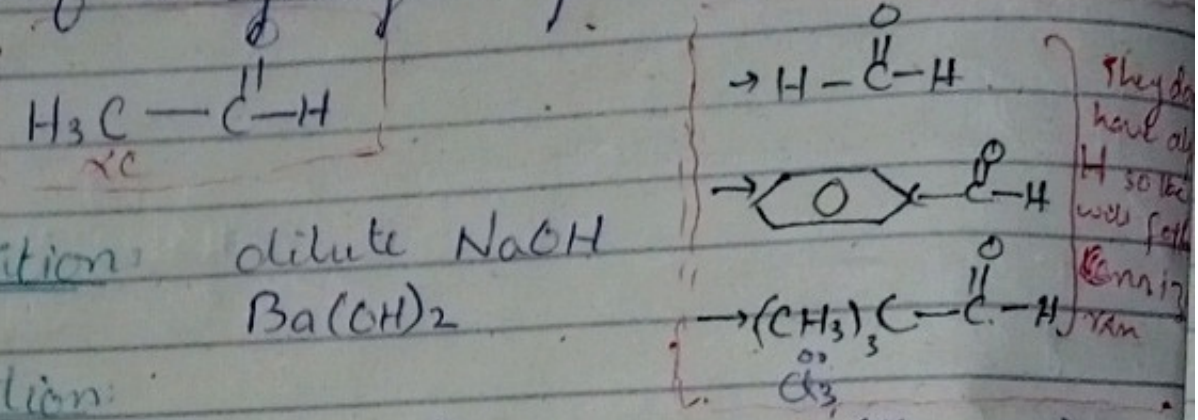
UNOF will form yellow crystals on reacting with basic Iodine

✗: $CH_3-CH_2-C(=O)-H$ ✗: $(CH_3-CH_2)_2-C=O$ (not methyl ketone)
✗: $CH_3-CH_2-CH_2-OH$ ✗: $CH_3-CH_2-CH(OH)-CH-CH_3$ (not 2 alkanol)

Aldol → aldehyde
Ketol → Ketone

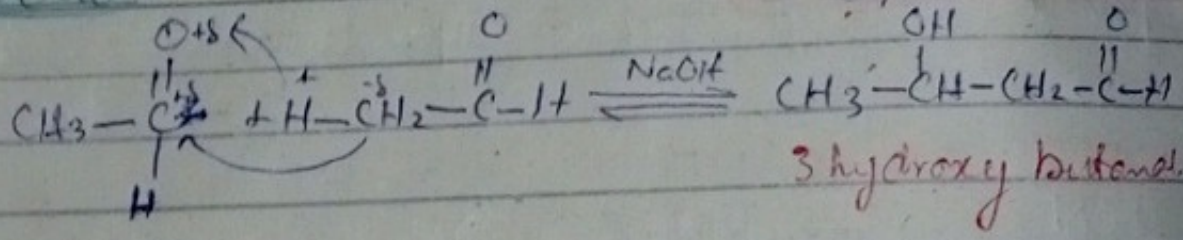
③ Aldol condensation:

↳ if α hydrogen is present → condition

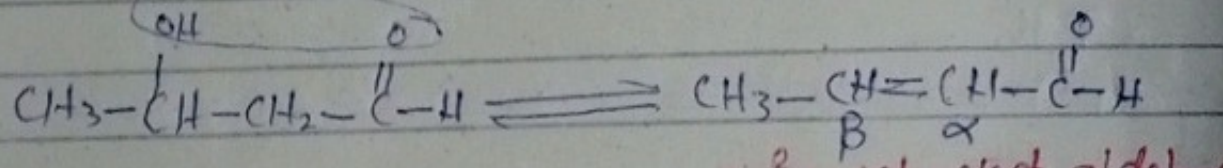


Condition: dilute NaOH
$Ba(OH)_2$

Reaction:



3 hydroxy butanal.



α-β unsaturated aldehyde
Crotonaldehyde.

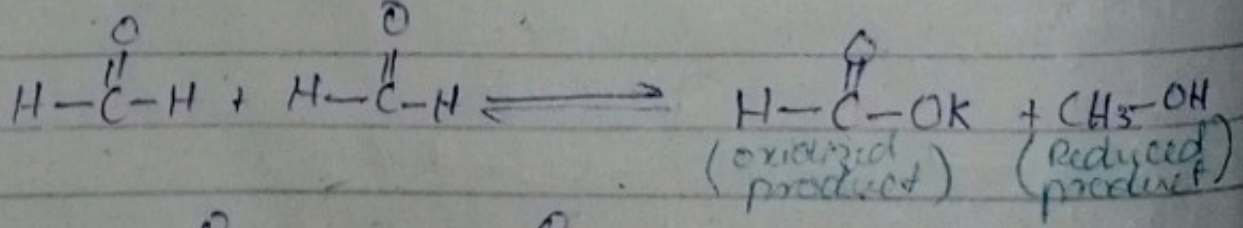
④ Cannizaro's reaction.

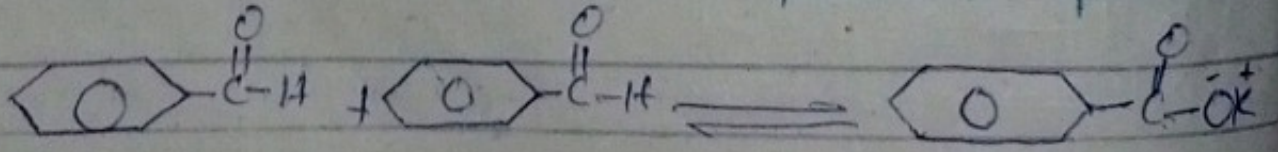
→ No α-H

→ Self oxidation-reduction

→ Disproportion reaction

Reaction:





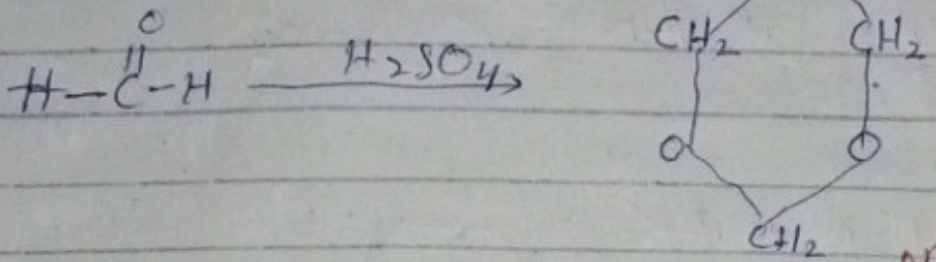
Acid Catalyzed Reaction:

① Polymerization:

→ Ketone ✗ → doesnot form polymer.

→ Aldehyde ✓

Reaction:



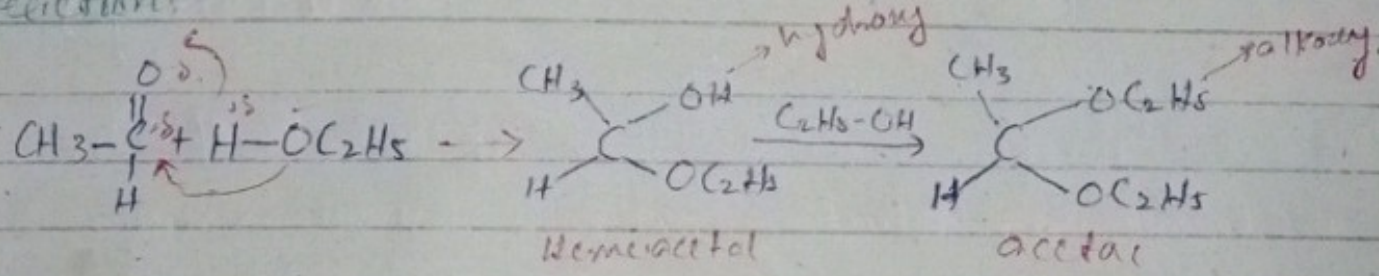
Trimer of formaldehyde
Meta formaldehyde

② Reaction with alcohol:

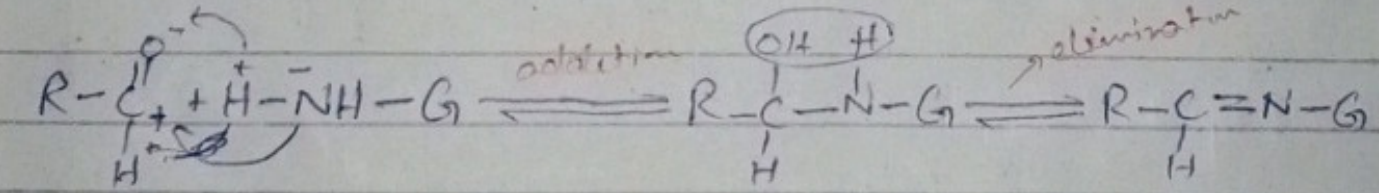
Ketone → doesnot show

Aldehyde → show.

Reaction:



Ammonia Derivative:



Name of derivative	formula	Reaction
Alkyl amine	$R-NH_2$	$R-C(=O)-H + H_2N-R \rightarrow R-C(=N-R)-H$ schiff's bases
Hydroxyl amine	NH_2-OH	$R-C(=O)-R + H_2N-R \rightarrow R-C(=N-OH)-R$ Ketone oxime.
Hydrazine	NH_2-NH_2	$R-C(=O)-H + H_2N-R \rightarrow R-C(=N-R)-H$ aldehyde hydrazone

phenyl hydrazine $H_2N-NH-C_6H_5$

$$R-\underset{R}{C}=O + H_2N-NH-C_6H_5 \longrightarrow R-\underset{R}{C}=N-NH-C_6H_5$$

hydrazone.

2,4-DNPH $H_2N-NH-C_6H_3(NO_2)_2$

Reaction:

$$R-\underset{R}{C}=O + H_2N-NH-C_6H_3(NO_2)_2 \longrightarrow R-\underset{R}{C}=N-NH-C_6H_3(NO_2)_2$$

2,4 DNP hydrazone

White (orange).

Reduction Of Aldehyde & Ketone:

1: Clemenson Reduction

just OH ⟶ NaBH4 or LiAlH4

alkane ⟶ Clemenson or wolf

$$CH_3-\overset{O}{\overset{\|}{C}}-H \xrightarrow{Zn-Hg/HCl} (alkane)\ CH_3-CH_3 + H_2O$$

ethane

2. Wolf Kishner:

ethylene glycol

$$H-\overset{O}{\overset{\|}{C}}-H \xrightarrow{KOH/N_2H_4} CH_4 + H_2O$$

methane

∴ the alkane will be according to no. of C in reactant

3: $NaBH_4$ / $LiAlH_4$ Reducing agent:

selective ⟶ $\overset{O}{\overset{\|}{C}}$

⟶ =

⟶ ≡

⟶ $\overset{O}{\overset{\|}{C}}-OH$

⟶ $\overset{O}{\overset{\|}{C}}-OR$

$$CH_3-\overset{O}{\overset{\|}{C}}-H \longrightarrow (alcohol)\ CH_3-CH_2-OH$$

ethanol

$$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 \longrightarrow \text{sec alcoh}\ CH_3-\overset{OH}{\overset{|}{C}}H-CH_3$$

Catalytic Reduction

$CH_3-\overset{O}{\overset{\|}{C}}-H \xrightarrow{H_2/Ni/Pt/Pd}$ (alcohol) CH_3-CH_2-OH

ethanol.

Oxidation Of Aldehyde & Ketone:

Ketone:

↳ to oxidize ketone strong oxidizing agent is required. (conc. HNO_3, $K_2Cr_2O_7/H^+$, $KMnO_4/H^+$

→ not weak or mild agent like fehling, benedict.

Symmetrical:

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + [O] \xrightarrow{KMnO_4/H^+} CH_3-\overset{O}{\overset{\|}{C}}-OH + H-\overset{O}{\overset{\|}{C}}-OH$

propanone

$H_2CO_3 \uparrow$

$CO_2 + H_2O$

↳ In a symmetrical ketone 2 diff acids will form.

mixture of acid

↳ only formic acid can further oxidize

Un symmetrical:

$CH_3-\overset{O}{\overset{\|}{C}}-CH_2-CH_3 + [O] \xrightarrow{KMnO_4/H^+} 2\,CH_3-\overset{O}{\overset{\|}{C}}-OH$

different acids: a: $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$

same acids: b: $CH_3-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$

different acids: c: $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-(CH_2)_3-CH_3$

Aldehyde:

→ strong oxidizing agent

$CH_3-\overset{O}{\overset{\|}{C}}-H + [O] \xrightarrow{KMnO_4/H^+} CH_3-\overset{O}{\overset{\|}{C}}-OH$

$CH_3-CH_2-\overset{O}{\overset{\|}{C}}-H + [O] \xrightarrow{KMnO_4/H^+} CH_3-CH_2-\overset{O}{\overset{\|}{C}}-OH$

→ Mild Oxidizing agent:

Tollen reagent (silver mirror test) (aliphatic + aromatic)

Fehling solution

Benedict solution (aliphatic aldehyde)

Reaction:

oxidation

→ Tollen:

$$R-\overset{O}{\overset{\|}{C}}-H + [Ag^{+1}(NH_3)_2]OH \longrightarrow R-\overset{O}{\overset{\|}{C}}-O^- + Ag^0$$

R.A O.A Reduction.

→ Fehling:

$$R-\overset{O}{\overset{\|}{C}}-H + Cu(OH)_2 + NaOH \xrightarrow{\text{Tartarate}} R-\overset{O}{\overset{\|}{C}}-O^- + Cu_2O$$

cupric blue cuprous red ppt

→ Bendict:

$$R-\overset{O}{\overset{\|}{C}}-H + Cu(OH)_2 + NaOH \xrightarrow{\text{Citrate}} R-\overset{O}{\overset{\|}{C}}-O^- + Cu_2O$$

Reaction for ketone:
Sodium nitro proxide test → wine red.

Carboxylic Acid:

↳ $-\overset{O}{\overset{\|}{C}}-$ ↙ ↘ $-OH$

↳ $R-\overset{O}{\overset{\|}{C}}-OH$

→ $C_nH_mO_2$

chain isomerism
Functional group isomer (esters)

Classification

- Aliphatic
  - monocarboxylic acid
    - → one COOH
    - $H-\overset{O}{\overset{\|}{C}}-H$ (Formic)
    - $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-OH$ (Propanoic)
    - $CH_3-(CH_2)_2-\overset{O}{\overset{\|}{C}}-OH$ (Butyric acid)
    - $CH_3-(CH_2)_3-\overset{O}{\overset{\|}{C}}-OH$ (Valeric acid)
    - $CH_3-(CH_2)_8-\overset{O}{\overset{\|}{C}}-OH$ (caprylic acid)
    - $CH_3-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH$
  - JOMSGA
  - dicarboxylic acid.
    - → 2 COOH
    - $OH-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-OH$ (oxalic)
    - $OH-\overset{O}{\overset{\|}{C}}-CH_2-\overset{O}{\overset{\|}{C}}-OH$ (malonic)
    - $OH-\overset{O}{\overset{\|}{C}}-(CH_2)_2-\overset{O}{\overset{\|}{C}}-OH$ (succinic)
    - $OH-\overset{O}{\overset{\|}{C}}-(CH_2)_3-\overset{O}{\overset{\|}{C}}-OH$ (glutaric)
    - $OH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH$
- Aromatic
  - mono
    - COOH
    - NO_2
    - COOH, OH
  - dicarb
    - COOH, COOH — phthalic
    - COOH, COOH — isothalic
    - COOH, COOH — terthalic

a: maleic acid $HO-\overset{O}{\overset{\|}{C}}-CH=CH-\overset{O}{\overset{\|}{C}}-OH$

b: malonic acid

c: Tartaric acid $OH-\overset{O}{\overset{\|}{C}}-\underset{OH}{\overset{H}{C}}-\underset{OH}{\overset{H}{C}}-\overset{O}{\overset{\|}{C}}-OH$ 2,3 dihydroxy butane 1,4 dioic

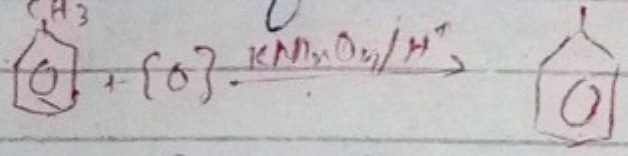
d: caproic acid → fatty acid → long chain mono carboxylic

Preparation method:

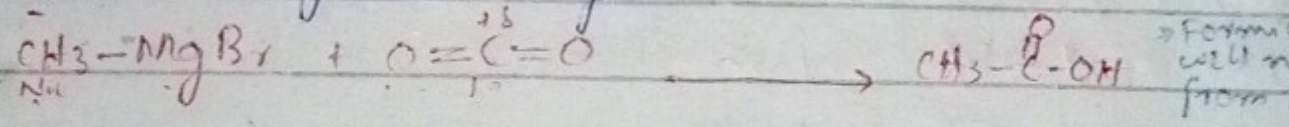
1: Oxidation of aldehyde

2: Oxidation of primary alcohl

3: Oxidation of toulene

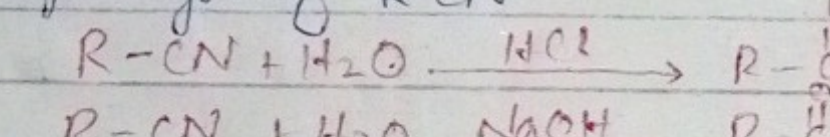


4: From Grignard reagent



» Formic acid will not form from RMgX.

5: Hydrolysis of R-CN:

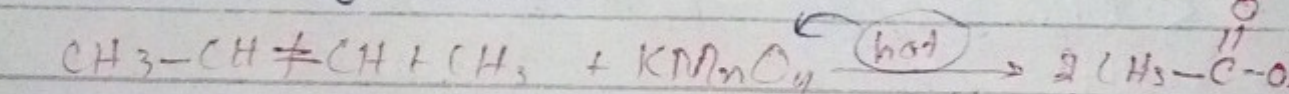


WOF will form ethanoic acid on hydrolysis?

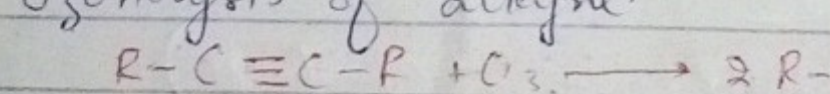
(a: methyl cyanide b: Ethylcyanide

c: Ethane nitrile d: both a & c.

6: Oxidation of alkene:



7: Ozonolysis of alkyne:



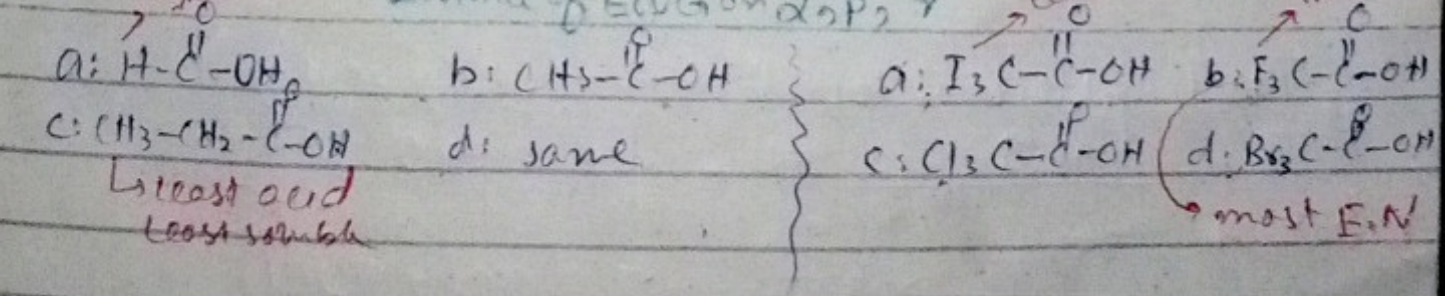
Acidity Of Carboxylic acid:

Acidity $\propto \frac{1}{\text{No. of C}}$

Acidity $\propto$ No of electron withdrawing GP on α C.

Acidity $\propto \frac{1}{\text{distance of EWG on } \alpha, \beta, \gamma}$

Acidity $\propto$ E.N of EWG on α-C.



a: CH_3-COOH — most acid

b: $Cl_3C-COOH$ — most acid

c: $Cl_2CH-COOH$

d: $ClCH_2-COOH$

a: NO_2-CH_2-COOH — most acid

b: FCH_2-COOH

c: $ClCH_2-COOH$

d: ICH_2-COOH

Physical Properties:

→ even C has higher M.pt than odd C.

→ Acetic acid → 5% solution → vinegar.

→ 17 C → ice like

→ glacial acetic.

→ H.B. $\propto \frac{1}{\text{No. of C}}$

→ Solubility $\propto \frac{1}{\text{No. of C.}}$

→ acetic acid → nonpolar (benzene) → diamer.

→ B.pt $\propto$ molar mass $3C > 2C$

→ odd < even > odd → m.pt $4C > 5C$

Reactions:

Electrophilic substitution (O—H):

$R-COOH$ + Na → $R-COONa + H_2\uparrow$

+ NaOH → $R-COONa + H_2O$

+ Na_2CO_3 → $R-COONa + CO_2 + H_2O$

a: $H-COOH$ reacts with Na

b: CH_3-COOH

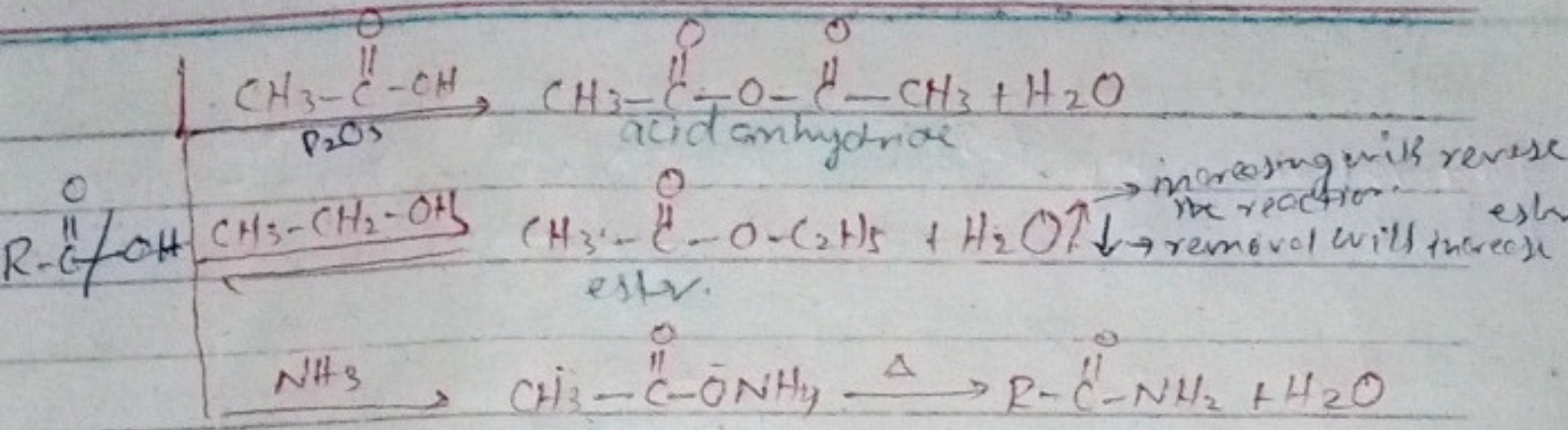
c: CH_3-CH_2-COOH

Nucleophilic substitution (C—OH)

$R-COOH$ + HCl → $CH_3-COCl + H_2O$

+ PCl_5 → $CH_3-COCl + HCl + POCl_3$

$LiAlH_4$ → hydrogen ions ... nucleophile



$CH_3-\overset{O}{\overset{\|}{C}}-\overset{-}{(OH)}$ → nucleophilic substitution reaction.

$CH_3-CH_2-\overset{+}{(OH)}$ → electrophilic substitution w.r.t alcohol

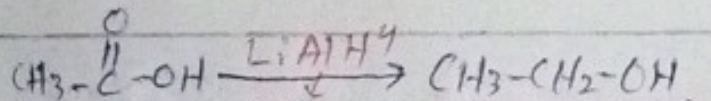
$H-\overset{O}{\overset{\|}{C}}-\overset{+}{(OH)}$ → Et subst w.r.t formic acid

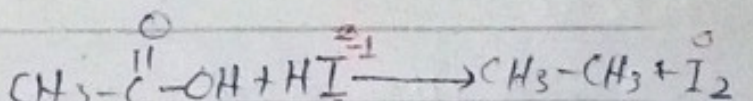
$CH_3-\overset{O}{\overset{\|}{C}}-\overset{-}{(OH)}$ → Nu subs w.r.t acetic acid.

Reduction Of Carboxylic Acid:

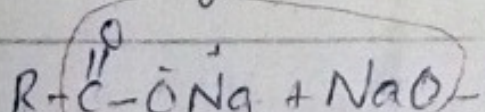
Reduction upto alcohol: (Partial reduction)

Reduction upto alkane. (complete reduction).





Decarboxylation Of salt:



NaOH → Caustic soda

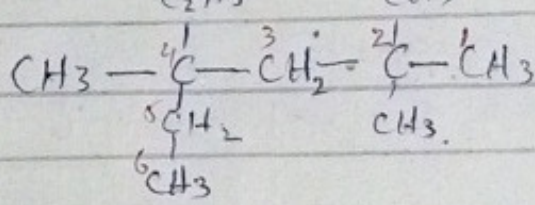
NaOH + CaO → Soda lime.

Inter Conversion Of Derivative:

Derivative	Hydrolysis (H_2O)	Alcoholysis (C_2H_5OH)	Ammonolysis (NH_3)
$R-\overset{O}{\overset{\|}{C}}-Cl$	$R-\overset{O}{\overset{\|}{C}}-OH + H_2O$	$R-\overset{O}{\overset{\|}{C}}-OR + HCl$	$R-\overset{O}{\overset{\|}{C}}-NH_2 + HCl$
$R-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-R$	$2R-\overset{O}{\overset{\|}{C}}-OH$	$R-\overset{O}{\overset{\|}{C}}-OR + R-\overset{O}{\overset{\|}{C}}-OH$	$R-\overset{O}{\overset{\|}{C}}-NH_2 + R-\overset{O}{\overset{\|}{C}}-$
$R-\overset{O}{\overset{\|}{C}}-OR$	$R-\overset{O}{\overset{\|}{C}}-OH + ROH$	$R-\overset{O}{\overset{\|}{C}}-OR + R-OH$	$R-\overset{O}{\overset{\|}{C}}-NH_2 + R-OH$
$R-\overset{O}{\overset{\|}{C}}-NH_2$	$R-\overset{O}{\overset{\|}{C}}-OH + NH_3$	—	—
$R-CN$	$R-\overset{O}{\overset{\|}{C}}-OH + NH_4$	—	—

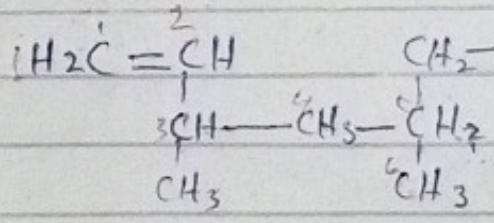
Nomenclature:

Alkane:



4 ethyl - 2,2,4 - Trimethyl hex

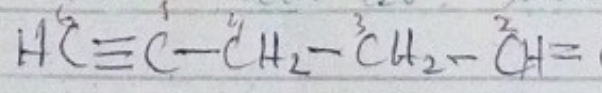
Alkene



3 ethyl - 3 methyl - hex-1-ene

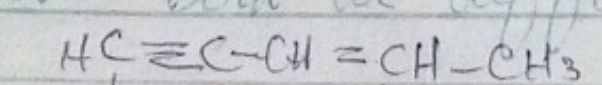
Alkyne: same.

When both at same position.

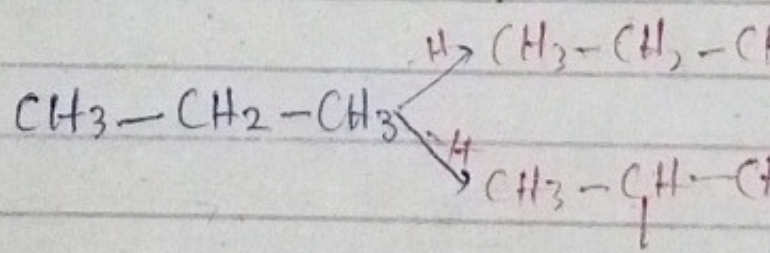


1-hexene - 5-yne.

When both at different position:



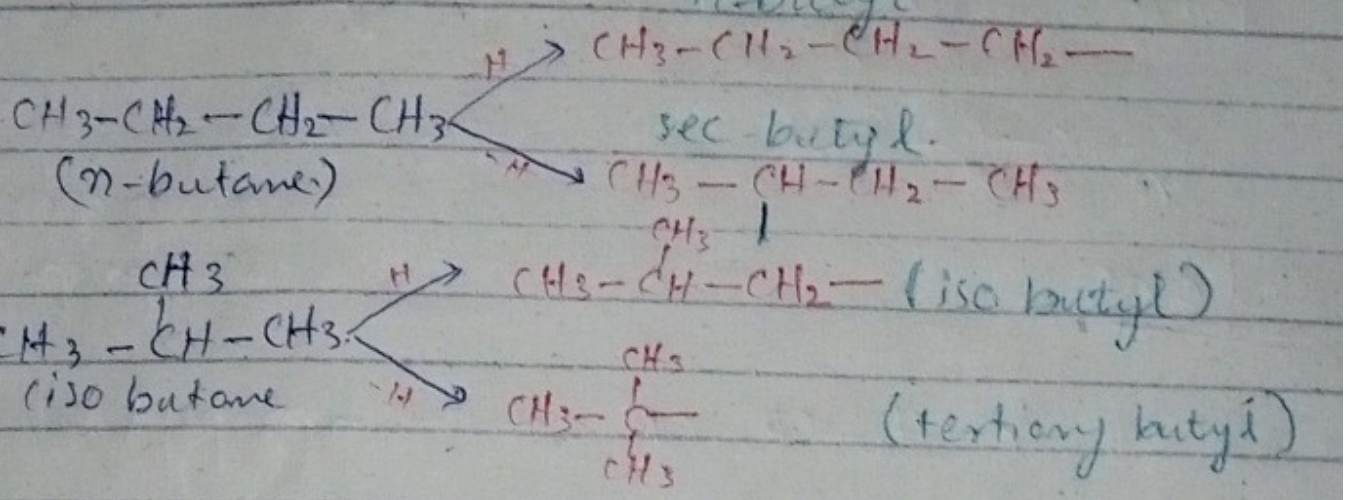
3-pentene - 1-yne.



(n propyl)

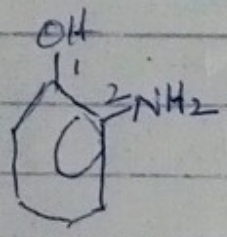
(iso butyl

Butane

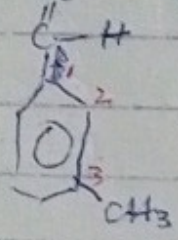


Nomenclature of Benzene:

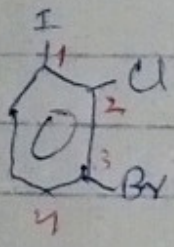
$\underset{1}{COOH} > \underset{2}{CN} > \underset{3}{-CHO} > \underset{4}{-C(=O)-R} > \underset{5}{OH} > \underset{6}{NH_2} > \underset{7}{OR} > \underset{8}{R}$



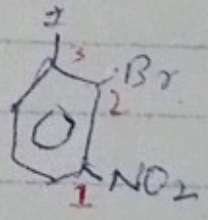
2 amino phenol.



3 methyl benzal aldehyde



3 bromo 2 chloro 1 iodo benzene



2 bromo 3 iodo nitrobenzene

Alcohol:

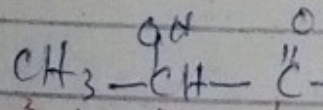
"=" Prefer OH

"≡"

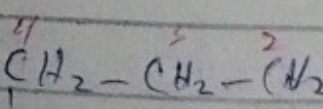
Prefer.

COOH, CHO, COR

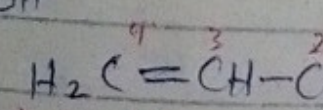
OH- → substituent



2 hydroxy propanoic acid.



4 hydroxy butanoic acid.



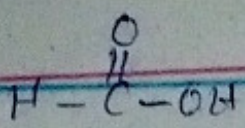
3 butene 1 ol.

Aldehyde:

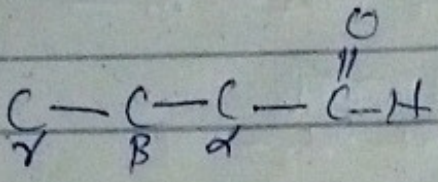
Common: derive from carboxylic acid

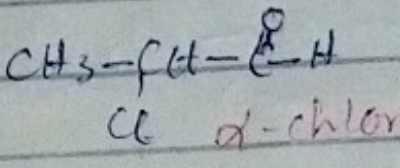
Acid → Aldehyde

ic → al



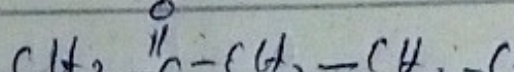
formic acid ⟶ formaldehyde



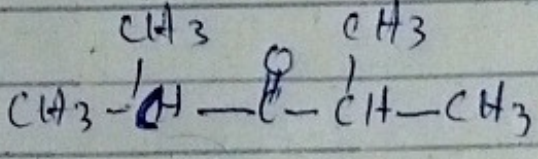


α-chloropropionaldehyde
2 chloropropanal

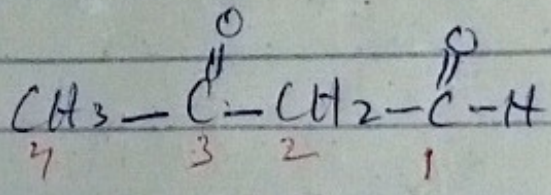
Ketone:



methyl n propyl ketone.



Diisepropyl ketone.



3-oxo-butanal
3-keto-butanal